Validation of Some Air Quality Study Methods for Measurement of Black Carbon and Organic Carbon and Identification of Their Sources

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Abstract

Fine particulate matter ($PM_{2.5}$) samples were collected from February 2010 to February 2011 in an urban monitoring site (CAMS2), Dhaka using Air Metrics samplers. The samples were analyzed for elemental composition by proton-induced X-ray emission (PIXE) & proton elastic scattering analysis (PESA) and particulate carbon was analyzed using the thermal optical reflectance method that divides carbon into four organic carbons (OC), pyrolized organic carbon (OP), and three elemental carbon (EC) fractions. It was found that BC and EC were well correlated (r^2 = 0.69) although the measurement technique was different. Similarly OC measured by carbon analyzer and OMH (organic matter containing hydrogen) measured by PESA were found well correlated (r^2=0.74) too. The "STATGRAPHICS" statistical graphics software was used to identify sources. From statistical calculation, it was found that the main sources of EC and OC were gasoline, diesel, biomass combustion and compressed natural gas (CNG).

Keywords: BC, EC, OC, OMH

1. Introduction

Climate change is manifesting itself in varied ways, especially in the world's polar regions and major mountain glacier systems, the latter being critical sources of fresh water and livelihoods for millions, if not billions, of people. It is also becoming clear that climate change is being driven not only by long-lived greenhouse gases such as carbon dioxide (CO_2) which are well mixed globally but also by what are known as short-lived climate forcers or SLCFs (methane, tropospheric ozone and black carbon), a suite of pollutants that reside in the atmosphere for an extremely short time by contrast, prominent among them being black carbon particles. Despite the short-lived nature of pollutants such as black carbon, they exert a significant influence on the climate system, especially on regional and local scales [1]. Like CO_2 [2], black carbon has also warming effect on regional scales.

Alternatively, OC effectively scatters light and may contribute significantly to both visibility degradation and the direct aerosol climatic forcing [3, 4]. A significant fraction of the particulate OC is water soluble, making it important in particle-cloud interactions [5, 6]. Finally, carbonaceous species have the potential to influence many heterogeneous reactions involving atmospheric particles and trace gases [7, 8]. Although BC and OC are important in atmospheric chemistry and physics, information concerning their spatial and temporal variability is quite limited. Most of the available data include only one particle size fraction, and the overall measurement period rarely exceeds a few weeks [9, 10]. Atmospheric aerosols are major carriers of black carbon (BC), sulfur, nitrogen and trace metals as well as crustal elements. These substances carried by particles pass through air, land and water and caused many effects including changes in climate and weather, fertilization of the oceans and land, acidification of lakes and health effects to humans.

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In this paper, a yearlong of daily $PM_{2.5}$ concentration was measured. The $PM_{2.5}$ samples were collected at a traffic-influenced site, Farm Gate in Dhaka, Bangladesh. Sampling of particulate matter has been done using Air Metric MiniVol samplers. The $PM_{2.5}$ samples were analyzed for BC, EC, OC and organic matter having hydrogen (OMH) using reflectometer, carbon analyzer and PESA. The main aim is to provide a correlation between BC and EC where BC and EC concentrations are based on reflectometer and thermal–optical carbon analyses, respectively. This paper presents the method validation of measurements of black carbon using PESA, reflectance method and carbon analyzer and to provide a correlation between OC and OMH where OC and OMH concentrations are based on thermal–optical carbon analyses and PESA method, respectively.

2. Materials and Methods

2.1 Site Description and Measurement Period

The measurements were carried out at an urban site at Dhaka. PM samplings were performed using Air Metrics MiniVol sampler for collecting $PM_{2.5}$ samples from the Farm Gate, continuous air monitoring station (CAMS-2) site in Dhaka city. Farm Gate is a hot spot site (Latitude: 23.76°N; Longitude: 90.39°E) due to the proximity of several major roadways intersection and large numbers of vehicles plying through the area [11]. The site is in the mixed area (i.e., commercial and semi industrial area). The Tejgaon industrial area is very near to the site.

The Air Metrics MiniVol sampler developed jointly by the U.S. Environmental Protection Agency (EPA) and the Lane Regional Air Pollution Authority was used for and $PM_{2.5}$ sampling [12]. At the Farm Gate site, the samplers were placed on the flat roof of the guardhouse of Bangladesh Agricultural Research Council (BARC). This location is known as CAMS site started from 2009 handled by Department of Environment (DoE) in Dhaka. The MiniVols were programmed to sample at 5 lpm through $PM_{2.5}$ particle